TROPHIC LEVEL CONCENTRATIONS OF CESIUM-137, SODIUM, AND POTASSIUM IN FOREST ARTHROPODS[1]

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Abstract. In a forest ecosystem experimentally tagged with ^{137}Cs, the trophic dynamic aspects of arthropod food chains are being investigated using radiotracer techniques. Cesium-137 concentrations in organisms in isotopic equilibrium with food have shown progressive reduction during dispersion through food chains, although the fractional transfer between food and consumer increased with each successive trophic level. The distribution of other alkali metals in arthropod food chains varied from that of cesium. Potassium concentrations in primary consumers (saprovores) were a factor of 3.5 higher than in detritus, although they decreased (similar to ^{137}Cs) by a factor of 0.5 from primary consumers to predators. Sodium concentrations in primary consumers increased by a factor of 17 above leaf litter, and by an additional factor of 1.5 in predators. There were no significant differences in ^{137}Cs to K ratios between arthropod trophic levels. Changing elemental composition of litter during decay, nutrient availability and assimilation efficiency by arthropods, and biological half-lives of each element were parameters affecting absolute concentrations and ^{137}Cs to K ratios in each trophic level.

Introduction

Nutrient levels at various positions in the trophic structure of ecosystems may reflect eventual availability to higher order consumers and, potentially, can affect dietary limitations on the productivity of consumer populations. Radioactive tracers have proven valuable in defining nutrient transfers between ecosystem components. The movement and ultimate distribution of radionuclides in ecosystems can provide information on food chain pathways, nutrient budgets, and nutrient turnover by biota at various trophic levels in the system. Radioisotopes of chemical analogs, e.g., ^{86}Rb and ^{137}Cs in the case of alkali metals, often have been utilized to elucidate the general behavior of related nutrients in ecosystems. Conversely, relationships have been sought between the movement of radioisotope contaminants and the stable chemistry of related elements in food chains to enable prediction of the fate of these isotopes in the environment, although insufficient emphasis has been given to application (Nelson 1964) of specific activity ratios in assessing the environmental consequences of radioactive contamination. Many of the environmental studies of ^{137}Cs (e.g., Hanson 1967, Whicker, Farris and Dahl 1967, Pendleton, Lloyd, Mays and Church 1964, and Nelson, this volume) have shown contrasting food chain movement and concentration of ^{137}Cs, K and particularly ^{137}Cs to K ratios in different ecosystems. These data demonstrate the need for additional information on other systems and suggest constraint in extrapolating particular results to other ecosystems and food chains of different structure and complexity.

This report presents data on the ^{137}Cs, K and Na levels in forest floor detritus food chains consisting of a leaf litter base, arthropod consumers (saprovores), and primary arthropod predators.

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The dominant trees (*Liriodendron tulipifera*) in this forest were tagged with ^{137}Cs in May 1962 (Auerbach, Olson and Waller 1964) establishing a chronic radiocesium input to associated food chains. Although levels of ^{137}Cs in foliage have decreased progressively in subsequent years, with soil acting as a major reservoir, the relatively rapid turnover of cesium by arthropods ($T_b \simeq$ several days) – in contrast to the minor long-term fluctuations in detritus (foliage) input – has resulted in an effective state of dynamic equilibrium between arthropods and their food bases. Eleven saprovore species and nine predator species were examined during all seasons from field collections spanning several years. Comparisons of specific activity measurements (^{137}Cs:total Cs) in arthropods with similar measurements on detritus in various stages of decay (L, F_1, F_2, and H horizons) have provided additional information on the food preferences of these organisms.

Concentrations (per unit dry wt) of ^{137}Cs in this cryptozoan community were reported to decrease through food chain transfer (Reichle and Crossley 1965). During the period of study, leaf litter averaged 24.7 pCi/mg, while mean concentrations of ^{137}Cs in saprovores and predators were 4.9 pCi/mg and 2.5 pCi/mg, respectively. Preliminary data indicated that food chain behavior of ^{137}Cs was not dissimilar from K, although information on the distribution of Na was inconclusive. These results suggested that ^{137}Cs to K ratios would not display the trophic level increases which were reported for some other terrestrial and aquatic food chains (Pendleton, Lloyd, Mays and Church 1964, Pendleton, Mays, Lloyd and Church 1965).

Additional data have been obtained on the stable- and radiochemistry of these arthropods. The steady-state whole-body concentrations of ^{137}Cs, K, and Na were examined with respect to their dependence upon several interacting factors: (i) in the case of ^{137}Cs, the stable chemistry of the organisms and the specific activity of their food bases, (ii) the rates of input (consumption) and digestive assimilation for each element, and (iii) the turnover (excretion) rates of each element by organisms. Biological half-lives and assimilation efficiencies for ^{134}Cs, ^{42}K, and ^{24}Na were determined for the cricket *Acheta domesticus* for comparison of the uptake and turnover of these elements by arthropods.

Ratios of ^{137}Cs to K decreased through trophic levels, although this reduction was not statistically significant between saprovores and predators. Experimental data on the availability of each element to higher order consumers have resulted in accurate predictions of trophic level changes in the ^{137}Cs to K ratio.

Methods

Arthropods were collected weekly in pitfall traps from September 1964 through April 1965. Similar collections were made of leaf litter, which were separated into various stages of decomposition. These samples formed the bases for ^{137}Cs analyses. Specimens from 1962 and 1963 were used for stable chemical analyses. Arthropods were analyzed for ^{137}Cs, Cs, K, and Na. Comparisons of these data assume no change in K and Na levels in components of this ecosystem during this period; constancy of these stable chemical concentrations has been analytically verified.

Whole-body homogenates of arthropods were processed to obtain dry weights, ash weights (24 hr at 450 C), and then dissolved in 0.1 N HCl for chemical analyses. Flame spectrophotometric techniques were used exclusively for Na and K. Radiocesium was assayed on a spectrometer system using a 3-in. Tl-activated NaI well crystal. Stable cesium analyses were performed by the Analytical Chemistry Division of Oak Ridge National Laboratory.

Oral dosing solutions for biological half-life determinations consisted of the chloride salts of ^{134}Cs, ^{42}K, or ^{24}Na dissolved in HCl diluted to 10 μCi/ml in distilled water and neutralized with $CaCO_3$. Young adult crickets, *Acheta domesticus*, were obtained from laboratory stocks and kept at 27 C during retention experiments. All animals were maintained on Purina protein-supplemented cricket mash.

Ratios of exchangeable ^{137}Cs to K from detritus were obtained by treating 2 g dry wt aliquots with 50 ml of 1 *N* Mg ($MgCl_2$) solution for a contact time of 24 hr. Under these conditions, Mg desorbs less than 6% of the ^{137}Cs from illitic soils (Tamura 1967). In the study area, illitic surface soils underlie and are intimately mixed with decomposing organic matter. The ratio of exchangeable ^{137}Cs to K was assumed to be similar to that available from organic matter to saprovore consumers.

Results

^{137}Cs Levels in the Forest Floor Community. Cesium-137 concentrations in trophic levels of the forest floor decomposer community were strongly affected by the annual input of fresh litter. Leaf litter on the forest floor showed maximum ^{137}Cs levels (pCi/mg) in mid-September, shortly after leaf fall. Thereafter, ^{137}Cs concentrations declined through October as a result of leaching, and then rose slightly due to selective retention of ^{137}Cs by microflora (Patten and Witkamp 1967), decomposition of organic materials, and mixing of high-level ^{137}Cs soil with organic horizons as a result of the activities of the soil fauna and rain splattering. Corresponding peaks of ^{137}Cs also appeared in the arthropod populations: in November, 60 days later, for saprovores and in December, 90 days later, for predators. The form of these curves was that of a dampened harmonic which stabilized by early spring and decreased slowly, but progressively, until leaf drop the following autumn. The temporal shift in peaks of ^{137}Cs concentration can result in apparent discrepancies in the overall pattern of ^{137}Cs concentration through trophic levels. This phenomenon results from the lag in ^{137}Cs transfer between trophic levels, and illustrates the necessity of interpreting ^{137}Cs concentrations in environmental samples within the context of this time-dependent relation. Although trophic transfer of a given amount of ^{137}Cs could be very rapid, especially if predation immediately followed a saprovore's consumption of tagged litter, more time is required for an entire trophic level to equilibrate with its food base. This equilibration period is typically a function of the turnover rate (i.e., the biological half-time) of the isotope in each trophic level.

Nutrient Levels in the Detritus Food Base. Nutrient levels in detritus are time-dependent, and vary according to the state of organic decomposition. Typically, nutrient concentrations are highest in newly fallen litter, but thereafter decrease with time. The overall nutrient content of detritus resulted from the differential decomposition and turnover of material in the various organic horizons (Table 1). The upper *L* layer represents essentially intact, but slightly decomposed, leaves. The F_1 and F_2 layers are successive stages of fragmentation and decomposition. The *H* horizon is humus of unrecognizable organic origin.

Table 1. Nutrient attributes of *Liriodendron tulipifera* leaf litter at various stages of decay, based upon assays of February 1966 collections. Data illustrate the general distribution in organic horizons of radiocesium, total cesium, potassium and sodium, as well as ash and organic constituents. Upper litter horizons typically comprise the food base of saprovorous arthropods considered in this study.

Litter Layer	Percent Ash	g dry wt/m^2	^{137}Cs (pCi/mg)	pCi ^{137}Cs/mg total Cs	Cs (μg/g)	K (mg/g)	Na (mg/g)
L	14.8	209.6	13.2	2.12×10^4	0.62	1.58	0.20
F_1	16.7	147.5	19.6	3.28×10^4	0.60	1.40	0.21
F_2	25.3	82.1	25.7	2.71×10^4	0.95	1.29	0.20
H	36.5	31.4	42.5	2.73×10^4	1.56	1.60	0.30

During decomposition, Na and K content of detritus remained relatively stable although both elements showed an increase (mg/g dry wt) in humus (Table 1). Both ^{137}Cs and stable cesium concentrations progressively increased through the litter profile. Sodium and potassium are readily leachable through both the organic and upper soil horizons. Cesium, however, is more tightly bound to mineral soils and is concentrated in the upper soil layers (Waller and Olson 1967). The successive increases in ^{137}Cs concentrations (pCi/mg) and total Cs concentrations (μg/g) in lower litter layers can be attributed to soil contamination, as is evidenced by greater ash composition. Approximately 19% of *L* layer ^{137}Cs is exchangeable (24 hr contact with 1 *N* Mg) opposed to 83% for K. This 4.4:1 (K:^{137}Cs) exchangeability ratio increased with each successive litter horizon. Although exchangeable amounts of K remained relatively constant, exchangeable Cs values decreased (13%, F_1; 7% F_2; and 4%, *H*) as a result of the increasing soil ^{137}Cs contribution to detritus – mineral-bound ^{137}Cs which is not organic associated and is essentially unavailable to saprovores.

Specific activities (pCi ^{137}Cs/μg total Cs) were relatively uniform in the lower litter layers; greater variation was evident in the *L* and F_1 horizons composed of more recently deposited organic materials. Fluctuation in Cs specific activities would be expected to occur as the introduced ^{137}Cs tag equilibrated with the stable Cs in the soil-plant phase of the ecosystem.

Nutrient Levels in Arthropod Trophic Levels. The results of whole-body chemical analyses of forest floor arthropods from the study area are given in Table 2. Cesium-137 data are expressed as pCi/mg dry wt, while Na and K values are given as μg/mg dry body wt. Arthropods were classed into two trophic groups: saprovores (detritus-feeders) and predators. Saprovore species included millipedes (*Apheloria, Cambala, Dixidesmus, Ptyoiulus,* and *Scytonotus*); crickets (*Ceuthophilus* and *Nemobius*); beetle (*Geotrupes*); wood roach (*Parcoblatta*); isopod (*Ligidium*); and the phalangid *Leiobunum*. For some of these species it was difficult to establish whether their food base consisted of leaf litter or microflora thereon. Nevertheless, chemical assays of detritus included both microbial and litter contributions. Predator species consisted of spiders (Araneida, essentially Lycosidae and Ctenizidae); beetles (*Dicaelus, Evarthrus, Hololepta, Sphaeroderus,* and *Staphylinus*); and the centipede *Otocryptops*.

In both trophic levels Na and K concentrations (Table 2) were in the range of from one to several parts per thousand (μg/mg dry wt). Mean K content of saprovores was 4.42 μg/mg, but only 2.35 μg/mg in predators. Mean Na concentrations increased from 3.57 μg/mg in saprovores to 5.38 μg/mg in predators. Similar to the initial litter trophic level, total Cs concentrations in arthropods were three orders of magnitude (parts per million or μg/g dry wt) lower than Na and K. Cesium-137 concentrations in the species examined averaged 5.95 pCi/mg in saprovores and 3.00 pCi/mg in predators. Specific activities during 1965 averaged 3.26×10^4 pCi ^{137}Cs/μg Cs in millipedes and 3.06×10^4 pCi ^{137}Cs/μg Cs in beetles (*Evarthrus*). Similarity of these specific activity values between trophic levels further supports the basic assumptions of our trophic model; i.e., that upper litter layers from the food base of saprovores, and that ^{137}Cs equilibrates rapidly within the animal compartments of these food chains.

Assimilation and Biological Half-Lives of ^{134}Cs, ^{42}K, and ^{24}Na. Studies of uptake and turnover of ^{134}Cs, ^{42}K and ^{24}Na by the cricket *Acheta domesticus*, served as a basis for comparison of the relative behavior of these elements in arthropod trophic levels. More extensive data on ^{134}Cs biological half-lives in a number of forest floor arthropods were reported by Reichle and Crossley (1965). Biological half-lives of ^{134}Cs (76.6 hr ± 9.9) and ^{42}K (69.2 hr ± 6.4) were not statistically different (Table 3). The biological half-life of ^{24}Na (46.6 hr ± 6.0), however, was appreciably shorter. Since a 1 to 1 ratio between ^{134}Cs and ^{42}K turnover was evident, no correction for differential turnover of these two elements was made in subsequent analyses of trophic level exchanges.

Assimilation values for each isotope were calculated from whole-body isotope retention patterns (log % initial radioactivity remaining through time) by using the standard mathematical "peel-off" procedure to separate the two-component retention curves into linear functions and

Table 2. Whole-body elemental composition of litter arthropods from the floor of a tulip poplar (*Liriodendron tulipifera*) forest at Oak Ridge, Tennessee. Concentrations of potassium and sodium are expressed as μg/mg dry wt (parts per thousand); ^{137}Cs concentrations are given as picocuries (10^{-12} curies) per mg dry wt. Trophic level separation groups species into saprovores (detritus-feeders) and their predators.

Taxa	Ash (% dry wt)	^{137}Cs (pCi/mg dry wt) ±S.E. (*N*)	K (μg/mg dry wt) ±S.E. (*N*)	Na (μg/mg dry wt) ±S.E. (*N*)	^{137}Cs:K (pCi/μg)	^{137}Cs:Na (pCi/μg)
Saprovores						
Apheloria montana	61.88	2.16 ± 0.22 (5)	5.75 ± 0.72 (6)	1.67 ± 0.12 (6)	0.37	1.29
Cambala annulata	43.03	7.08 ± 4.10 (47)	3.36 ± 0.07 (3)	1.98 ± 0.06 (3)	2.11	3.57
Ceuthophilus gracilipes	9.54	4.91 ± 1.53 (22)	6.80 ± 1.60 (3)	5.11 ± 0.42 (3)	0.72	0.96
Dixidesmus erasus	47.81	11.01 ± 4.93 (21)	6.31 ± 1.32 (2)	1.96 ± 0.10 (2)	1.74	5.62
Geotrupes spp.	4.01	0.57 ± 0.19 (10)	0.59 ± 0.22 (4)	3.34 ± 0.66 (4)	0.97	0.17
Leiobunum flavum	6.93	10.59 ± 1.46 (84)	6.84 ± 2.17 (3)	5.34 ± 1.04 (3)	1.55	1.98
Ligidium sp.	28.83	5.47 ± 1.66 (21)	6.72 (1)	3.60 (1)	0.82	1.52
Nemobius maculatus	11.70	5.44 ± 1.92 (16)	3.80 ± 1.78 (3)	6.67 ± 3.48 (3)	1.43	0.82
Parcoblatta sp.	6.42	5.59 (1)	2.24 (1)	6.64 (1)	2.50	0.84
Ptyoiulus impressus	44.26	7.08 ± 4.10 (47)	3.76 ± 0.16 (7)	1.90 ± 0.08 (7)	1.88	3.73
Scytonotus granulatus	25.25	5.51 ± 0.76 (50)	2.45 (1)	1.01 (1)	2.25	5.45
Predators						
Araneida	8.13	7.47 ± 2.94 (28)	6.45 ± 0.79 (8)	6.91 ± 0.25 (8)	1.16	1.08
Dicaelus spp.	3.83	0.79 (1)	0.88 ± 0.12 (3)	5.70 ± 0.20 (3)	0.90	0.14
Evarthrus spp.	3.22	0.74 ± 0.34 (9)	1.84 ± 0.26 (4)	4.20 ± 0.23 (4)	0.40	0.18
Hololepta sp.	4.02	0.72 (1)	0.82 (1)	2.61 (1)	0.88	0.27
Otocryptops sexspinosus	7.20	6.76 ± 1.73 (33)	2.28 ± 0.46 (5)	11.74 ± 0.52 (5)	2.96	0.58
Sphaerodemus stenostomus	3.00	0.53 ± 0.06 (12)	2.12 (1)	3.71 (1)	0.25	0.14
Staphylinus badipes	4.32	3.99 ± 2.42 (2)	2.03 (1)	2.78 (1)	1.96	1.44

Table 3. Biological half-lives of sodium-24, potassium-42, and cesium-134 in the cricket *Acheta domesticus* (27 C). Efficiencies of isotope assimilation from water are derived from isotope retention patterns.

Isotope	Assimilation (%) ±S.E. (*N*)	Biological Half-Life (hr) ±S.E. (*N*)
^{24}Na	89.8 ± 7.7 (11)	46.6 ± 6.0 (9)
^{42}K	96.6 ± 1.0 (11)	69.2 ± 6.4 (11)
^{134}Cs	73.0 ± 1.1 (9)	76.6 ± 9.9 (7)

from their intercepts calculating the percentage unassimilated isotope in gut and that proportion assimilated by body tissue (Table 3). Only slight discrimination occurred between ^{24}Na (89.9% ± 7.7) and ^{42}K (96.6% ± 1.1) assimilation; both values, however, were significantly higher than that for ^{134}Cs assimilation (73.0% ± 1.1). The resulting assimilative ^{134}Cs to ^{42}K ratio of 0.75 was subsequently used to predict the change in the ^{137}Cs to K ratio for arthropods at each trophic transfer.

Discussion

^{137}Cs, K, and Na Concentrations in Trophic Levels. For comparison of nutrient values in the various trophic levels, mean element concentrations of only the *L* and F_1 litter horizons for the September to March period were used as the reference base. Cesium-137 concentrations decreased by a factor of 0.67 from litter (17.94 pCi/mg) to saprovores (5.95 pCi/mg). Presumably, much of the ^{137}Cs in detritus was associated with mineral soil and unavailable to consumer organisms. Concentrations of ^{137}Cs in the predator trophic level (3.00 pCi/mg) showed a further decrease from saprovores by a factor of 0.50. Potassium concentrations in the saprovore trophic level (4.42 μg/mg) were a factor of 3.51 higher than in detritus (1.26 μg/mg) but thereafter dropped similar to ^{137}Cs by a factor of 0.47 to 2.35 μg/mg in the predator trophic level. Sodium concentrations progressively increased through all trophic levels. Sodium concentration in the saprovore trophic level (3.57 μg/mg) was nearly 18 times greater than that of the detritus food base (0.20 μg/mg). In arthropods, Na concentration continued to increase by a factor of 1.51 between the saprovore (3.57 μg/mg) and predator (5.38 μg/mg) trophic levels.

The movement and concentration of ^{137}Cs and K were similar in arthropod trophic levels. Apparent differences in the transfer of these elements between detritus and saprovores resulted from differential availability from detritus, and are discussed subsequently in consideration of Cs to K ratios in trophic levels. The pattern of Na concentration in trophic levels varied from that of ^{137}Cs and K. Sodium concentrations increased with each trophic exchange. Absolute magnitude of trophic concentration of each element was subject to the variable ash composition of trophic levels, since concentrations were expressed per unit dry body wt. Mean saprovore ash content (26%) was considerably higher than other trophic levels because this group was dominated by species (millipedes and isopods) with heavily calcified exoskeletons. Similar concentration patterns persisted when element content was expressed per unit ash-free dry wt.

It is difficult to explain the trophic level concentration of Na within the context of turnover rates and assimilation efficiencies alone. The high digestive assimilation and rapid biological half-life of ^{24}Na compared to ^{134}Cs and ^{42}K (Table 3) suggest that Na concentrations should decrease through successive trophic exchanges even more rapidly than ^{137}Cs and K. Such is

Table 4. Cesium-137 to potassium ratios in trophic levels of a forest floor arthropod community, expressed as pCi ^{137}Cs per μg K ± S.E. Litter ratio adjusted to the exchangeable cation ratio. Assimilative ratios represent further adjustment for differential assimilation of each element (Table 3) by the next trophic level.

Food Base	Total	Exchangeable	Assimilative
Leaf litter	14.25	2.58	2.08
(N = 4)	±4.12	±0.80	±0.65
Saprovores	1.49	*a*	1.20
(N = 11)	±0.21		±0.17
Predators	1.22	*a*	0.98
(N = 7)	±0.36		±0.30

[a]Predatory transfer of cesium is highly efficient, and it appears feasible to use element concentration in saprovores as an estimate of concentration of food intake of predators (Crossley and Shanks 1966).

not the case for *Acheta* (4.38 μg Na/mg vs 10.94 μg K/mg) nor for the overall trophic ordination (Table 2) when compared with the detritus food base (Table 1). One explanation for the observed Na concentration in food chains might be the nutritive demands of the consumer. If Na is a conservative nutrient in the diet, saprovores could be eating excessively to satisfy Na requirements from a low initial concentration in food. Consequently, actual ^{137}Cs and K uptake from detritus might be lower than that projected from laboratory experiments. Fungal mycelia generally contain more K than any other metal and Na does not appear to be an essential element (Lilly 1965). Therefore, it is unlikely that mycoflora on detritus would appreciably alter the Na to K ratio of the saprovore food base. Once critical Na concentrations have been attained by saprovores, only slight subsequent increase occurs in the predator trophic level (1.5 increase relative to dry wt and 1.2 relative to the ash-free dry wt concentration). Roeder (1953) cited studies which showed a high correlation in insects between Na to K ratios of diet and hemolymph, although carnivorous insects generally had higher Na to K ratios than did herbivores. This pattern is similar to that of these detritus-based food chains, with the exception of high Na concentration between detritus and saprovores.

^{137}Cs to K Ratios Between Trophic Levels. From September 1964 to March 1965, ^{137}Cs concentrations in the L and F_1 litter horizons averaged 17.94 pCi/mg ± 5.52. The ^{137}Cs to K ratio (pCi ^{137}Cs to μg K) in this litter averaged 14.25 ± 4.12 (Table 4). The ^{137}Cs to K ratio (mean of species ratios, Table 2) decreased by a factor of ten to 1.49 ± 0.21 in saprovores, and thereafter decreased to 1.22 ± 0.36 in predators. There was no significant difference between the ^{137}Cs to K ratios of saprovore and predator trophic levels. The change in the ^{137}Cs to K ratio between litter and saprovore trophic levels was due to the fact that ^{137}Cs and K were not equally available to saprovore consumers. The ratio of organic exchangeable ^{137}Cs to K was 2.58 ± 0.80. The ratio of available ^{137}Cs to K from the detritus food base was considerably lower than the total elemental composition indicated. The cricket, *Acheta domesticus*, displayed a discrimination between uptake (assimilation) of ionic ^{134}Cs and ^{42}K. If this assimilation factor of 0.75 for ^{134}Cs:^{42}K is generally applicable to the arthropod trophic levels, then it would contribute toward a further reduction in the ^{137}Cs to K ratio between litter and saprovores. By adjusting the total ^{137}Cs to K ratio of litter for differential exchangeability and assimilation of each element, a predicted ^{137}Cs to K ratio of 2.08 ± 0.65 is obtained for saprovores. This predicted ratio is not significantly different from the ratio (1.49 ± 0.21) actually determined from independent chemical analyses. Similarly, the ^{137}Cs to K ratio of saprovores was adjusted to a hypothetical assimilative ratio available to the predator trophic level. There was no significant difference between the predicted predator ratio (1.20 ± 0.17) and the ratio observed (1.22 ± 0.36).

Comparison with Other Trophic Level Studies. For certain terrestrial ecosystems – especially the arctic lichen-caribou-Eskimo food chain (*e.g.*, Hanson 1967, Hanson, Watson and Perkins 1967) – fallout ^{137}Cs has been found to increase in concentration in organisms of higher trophic position. However, Hanson (1967) stressed that every ecosystem has unique features which may result in different radionuclide cycling characteristics. Cesium-137 and ^{137}Cs to K ratios may increase in several aquatic and terrestrial food chains (Pendleton 1965, Pendleton, Mays, Lloyd and Church 1965). Pendleton, Lloyd, Mays and Church (1964) reported a trophic level ^{137}Cs increase factor of 3.4 in cougars feeding upon mule deer and a similar, but slightly higher, increase in the ^{137}Cs to K ratio. Recognizing the time-associated factors affecting the concentrations of fallout radionuclides in trophic levels, Whicker, Farris and Dahl (1967) found that ^{137}Cs levels in mule deer approximated mean levels in vegetation (0.24 pCi ^{137}Cs/g fresh muscle per pCi ^{137}Cs/g air-dry vegetation). A ^{137}Cs to K concentration factor of 0.9 between diet (rumen samples) and muscle was also reported for mule deer (Dahl, Whicker, Farris and Hakonson 1967). Hanson (1967) also found nearly equal ratios of pCi ^{137}Cs/g K in caribou and Alaskan Eskimos during 1964.

In contrast, the concentration of ^{137}Cs in arthropod food chains generally decreases from plant to primary consumer to predator. Crossley and Howden (1961) reported mixed species populations of insects to have ^{137}Cs concentrations about 70% of that in plants. More recent data (Crossley, this volume) has supported these results and shown a further decrease in ^{137}Cs concentrations between herbivorous and predaceous arthropods. In the canopy arthropod populations of a *Liriodendron tulipifera* forest tagged with ^{137}Cs, Reichle and Crossley (1967) found a general reduction in ^{137}Cs concentrations during food chain transfer with foliage-feeding insects having the highest concentrations, omnivores intermediate concentrations, and predators the lowest concentrations per unit wt. A similar trophic level relationship in concentrations of ^{137}Cs was also reported for the forest floor arthropods in this same forest (Reichle and Crossley 1965). Typically, detritus-feeders (saprovores) have shown a greater reduction in ^{137}Cs concentrations from their food base than have foliage-feeders (herbivores). This paper shows that Na levels increased through successive trophic levels of forest floor arthropod food chains. Cesium-137 concentrations in saprovores were lower than in detritus, although K concentrations increased. Both ^{137}Cs and K concentrations showed a reduction between the saprovore and predator trophic levels. The ratio of ^{137}Cs to K decreased in the initial detritus-to-arthropod transfer but, thereafter, did not change significantly between arthropod trophic levels.

Until additional radiochemical data become available for other food chains of different structure and complexity, any generalization of the trophic level behavior of ^{137}Cs would appear presumptuous. Considerable information also is needed on stable element composition in trophic levels before the applicability of specific relationships, i.e., ^{137}Cs to K ratios, can be fully interpreted.

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